SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY JUVENILE SALMONIDS

Abbott (Peter) P. Klimley

Final Selection Panel Review

Proposal Title

#0313: SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY
JUVENILE SALMONIDS

Funding:

Fund in part
Amount: **$1,500,000**

**Public comments received from the proposal applicants
identified a budgetary factor that warrants a revised funding
recommendation from the Selection Panel. The Technical
Synthesis Panel's analysis and the subsequent Selection Panel
review overestimated the savings from deleting the saltwater
array components.**

**There are four other studies that came up after this proposal
was submitted that support this project: A USFW project, a
Port of Oakland project, a science group working on dredging
in the San Francisco Bay, and a UC Davis sturgeon study.**

**The Selection Panel suggested reduced funding for this project
but feels that it is a viable project for CALFED to support
because it has long-term beneficial impacts. The Selection
Panel feels that this project supports a substantial paradigm
shift that will contribute to much of the fishery work in the
Central Valley and will become a new approach in the future.
Total recommended project funding is $1,500,000.**

Public Comments

The following public comments were received for this proposal.

UNIVERSITY OF CALIFORNIA, DAVIS

BERKELEY · DAVIS · IRVINE · LOS ANGELES · MERCED · RIVERSIDE · SAN DIEGO · SAN FRANCISCO   SANTA BARBARA · SANTA CRUZ

DEPARTMENT OF WILDLIFE, FISH, AND CONSERVATION BIOLOGY
COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION
FAX: (530) 752-4154

ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616-8751

1 June 2005

Dr. Ladd Lougee
Research Coordinator
California Bay-Delta Authority
CALFED Science Program
650 Capitol Mall, 5th Floor
Sacramento, CA 95814

Dear Dr. Lougee:

This note is in regard to the proposal, "Survival and migratory patterns of Central Valley juvenile salmonids" (#0313), on which I am principal investigator (PI). Bruce MacFarlane, Steven Lindley, and Arnold Amman of the National Marine Fisheries Service (NMFS), Santa Cruz are co-PIs on this project. We are concerned about an apparent mistake in calculating the recommended funding relative to the scope of the proposed research.

The Technical Synthesis Panel "concluded that about 40% of the proposed budget ($800,000) has been allocated to deploying ultrasonic receiver arrays in coastal waters" and recommended that the project be funded, contingent on the exclusion of the coastal arrays, at a reduced amount of "$2,150,766 – $800,000 = $1,350,766." The panel recommended funding in the order of $1,300,000 in their summary. The two sections, excised from the award, the deployment and maintenance of the array across the mouth of the bay (Task 1b, $165,036) and three coastal arrays (Task 2b, $469,479), add up to a sum of $634,515, not $800,000, and which upon subtraction from the total budget, leaves a total of $1,516,251 not $1,350,766. This deficit of $216,251 ($1,516,251 - $1,300,000) would force us to reduce at the last moment the scope of the study, which was carefully conceived over a period of multiple months. We are concerned that the proposed work cannot be completed as presented within the proposal given this budget.

There is some good news with respect to the creation of a watershed-wide array of monitors. The National Marine Fisheries Service has recently acquired the equipment (monitors, moorings, etc.) for the monitors to be placed across the mouth of San Francisco Bay – and this would now be considered a matching contribution of $105,324 to our grant, if funded. CALFED would now need only pay for the chartering of a captain and vessel to enable us to interrogate the monitors – an additional cost of only $59,712 to the grant (i.e., resulting in a total cost of $1,575,963).

The Synthesis Panel recommended the coastal array be excised based partly on the advice of one external reviewer. However, two of reviewers recommended that more tags be used in the study to give the results greater statistical confidence. Given the limited release period (1 month) and our personnel constraints, we would not be able to place 200 more beacons on each species (i.e., 400 beacons per Chinook and steelhead), but could tag 100 more smolts of each species. This would increase the amount in Task 3a by $116,637 and Task 3b by $119,397, resulting in an overall cost of the grant of $1,811,997, without the coastal array (which costs $469,479). We present this option to you based on the reviews.

We are bringing this matter to the attention of the Technical Synthesis Panel to ensure that adequate funds are available to fully complete this highly worthwhile project. This telemetric study is likely to evolve into a synergistic collaboration between private industry, California Department of Fish and Game, California Department of Water Resources, and U.S. Fish and Wildlife Service. Members of these organizations are keen to place individually coded ultrasonic tags on other fishes and monitor their movement by supplementing our widespread array in order to answer questions germane to the conservation of species in the Sacramento/San Joaquin watershed.

We would like to provide you with a recently written article, entitled "Estimating survival and migration rates with ultrasonic tagging." The reviewers of our proposed study felt that its least well described phase was the method(s) of tag-return analysis. They would have liked a model presented that showed the potential physical and anthropogenic factors, which might impact the rates of smolt migration and survival. We apologize for not doing so – it was difficult in a Project Description limited to 20 pages to give all phases of the study their proper attention. Steven Lindley, a co-PI of the project, recently prepared, in response to the concern of the reviewers, a more detailed description of the methodology used to analyze tag detections and created the recommended graphical model (see Fig. 3). He presented this information in a workshop earlier this week on coded-wire

tagging of salmonids, sponsored by CALFED and attended by scientists throughout California. The attendees were very excited at the prospect of having a study in the watershed implementing this new technology.

With regards,

A. Peter Klimley, Ph.D.
Adjunct Associate Professor
University of California, Davis

With regards,

R. Bruce MacFarlane, Ph.D.
Supervisory Research Fisheries Biologist
National Marine Fisheries Service
Santa Cruz, California

Included: 3 X copies of Lindley, S., P. Klimley, B. MacFarlane, and A. Amman. 2005. Estimating survival and migration rates with ultrasonic tagging. CALFED Workshop, Sacramento, 4 pp.

Estimating survival and migration rates with ultrasonic tagging

Steve Lindley, Pete Klimley, Bruce MacFarlane and Arnold Amman

email: Steve.Lindley@noaa.gov

27 May 2005

1 Background

We have proposed to estimate survival and migration rates of late-fall-run chinook salmon and steelhead smolts from Battle Creek through the coastal ocean using ultrasonic transmitters and data-logging hydrophones. The goals are two-fold: to *describe* migration and survival rates at the scale of river reaches, and to *explain* variation in these rates. Several hundred steelhead and chinook smolts will be tagged with small, uniquely identifiable ultrasonic pingers and tracked with moored data-logging hydrophones deployed along migration corridors in the Sacramento River, Delta, Bay and coastal ocean. The proposal was among those recommended for funding in the recent CALFED Science Program PSP, albeit at a reduced amount. This brief document provides an overview of the proposal, with emphasis on data analyses. For more details on technology and justification, please contact Pete Klimley for a copy of the proposal.

Figure 1. A: Vemco V7 tag. B: Downloading data from VR2 receiver in SF Bay. Green arrow points to receiver. C: Juvenile steelhead immediately after surgical implantation of V7 tag. D: Same fish after 1 month.

2 Tagging technology

We will use Vemco V7 tags and VR2 receivers. Each V7 tag emits a series of acoustic pulses at 69kHz that are decoded by the VR2. The VR2 logs each tag code along with the time of observation. Range is on order of 300 m. Tags are implanted surgically into the peritoneal cavity of fish with fork lengths > 150 mm (Figure 1). The tagging has little effect on fish survival and swimming performance (A. Amman, unpublished data). The movement of tagged fish will be monitored by an array of VR2 hydrophones deployed along migration routes between Battle Creek and the coastal ocean (Figure 2).

3 Analysis

The goal of the work is to quantify survival and movement rates and explain any interesting variation in these rates.

Figure 3 sketches out our simplified view of how movement and survival are determined. Movement rate varies due to the interaction of the animal with its environment, through its behavior. We can't observe the behavior directly (e.g., stopping to feed among emergent vegetation), only the movement rate as indicated by the time taken to pass between receivers. We hope to explain variation in movement by including readily-measured and biologically meaningful explanatory variables in a simple model of movement rate (some variables and data sources we are considering are described in Table 1). For example, we might hypothesize that fish dally in areas with lots of natural vegetation and speed through areas with armored shores. Obviously, we expect river velocity to influence movement rate, as well as time of day, and it should not be surprising if water clarity or temperature influences migration rate. We hypothesize that survival through a reach is largely determined by predation and water diversion. Other factors, such as point sources of pollutants, could
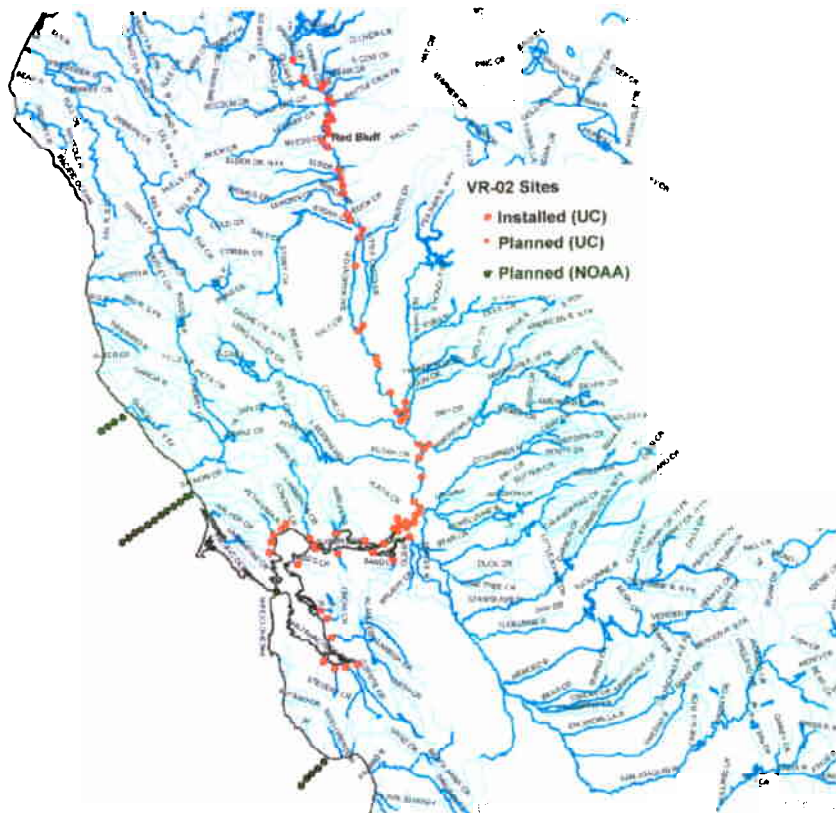
1

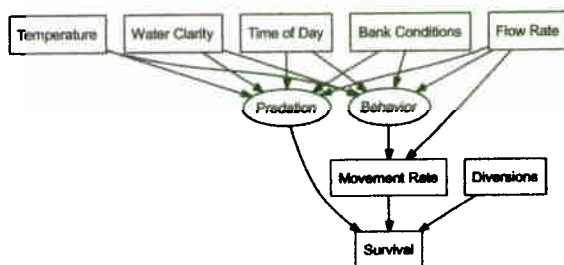**Figure 2.** Map of proposed receiver locations.

Figure 3. Conceptual model of how measurable environmental variables influence movement rate and survival rate through their influence on the behavior of the juvenile salmonids and the predators with which they interact.

also kill fish, but the effects of these might not be realized until after the fish has left the reach. The abundance and activity of predators is probably influenced by the same factors affecting the movement rate of the salmonids.

Our general approach to data analysis is to develop statistical models for the data that include explanatory variables that influence underlying mean rates (generally in a linear fashion). These models will be compared to "null" models, where rates are constant among reaches or where each reach is characterized by a unique rate. If measured environmental variables are important influences on rates, then the models including these variables should be preferred over the null models by an appropriate statistical criterion (e.g., AIC or BIC). If the null model with reach effects is best, it might be worth looking at reaches with significantly low survival rates for clues about mechanisms that aren't reflected in the environmental variables chosen prior to data collection.

3.1 Analysis of migration rates

Analyzing the migration rate data is relatively straightforward. The fundamental observations are passage times of individual fish between receivers. The migration rate of a fish through reach is simply the distance between re-

2

Table 1. Summary of river reach-level environmental data and sources uncovered with casual digging.

Variable	Source	Description
Water velocity	USGS	model local velocities with gage data
	various	hydrodynamic model outputs
Water temperature	UC Davis	measured by each hydrophone mooring
Riparian vegetation	CDF	25 m resolution, derived from black and white air photos and Landsat TM
	ACoE	0.6 m resolution, derived from color air photos
Rip-rap	ACoE	0.6 m resolution, derived from color air photos

ceivers divided by the time taken to make the trip. We want to know if migration rate varies among reaches, and if so, why. A null hypothesis is that migration rates are constant. We might expect, however, that migration rates are influenced by flow, time of day (or proportion of the travel time spent in darkness), shoreline conditions (e.g., amount of emergent vegetation or rip-rap), distance from the release site (perhaps migration accelerates as fish approach the ocean), temperature, turbidity, and quirks of the individual fish. The most straight-forward way to evaluate these hypotheses is to model the observed migration rates by multiple linear regression. Evidence for the significance of an effect would be a 90% confidence interval for the related parameter that did not include zero; the relative importance of different effects could be evaluated by comparing the magnitudes of the parameter estimates. An alternative linear model would use reach effects rather than covariates (i.e., each reach would be assumed to have a different migration rate).

3.2 Analysis of survival rates

Analyzing survival rates is a bit more complicated, because the probability of recording the passage of a fish at some point depends on both the survival of the fish to that point and the probability that it is detected given that it survived. The data (counts of individual fish passing detection points) are viewed as arising from the combined effects of reach-specific survival probabilities and receiver-specific detection probabilities (Figure 4 shows a simplified case). The fate of individual fish can be represented by a capture history, which is simply a string of 1's and 0's indicating at which points the individual was detected. The survival and detection probabilities define a multinomial distribution for the capture histories, and these probabilities can be inferred from the observed fates of a group of tagged fish via the maximum likelihood method. The situation described in Figure 4 is modeled by the Cormack-Jolly-Seber model for live recaptures, the
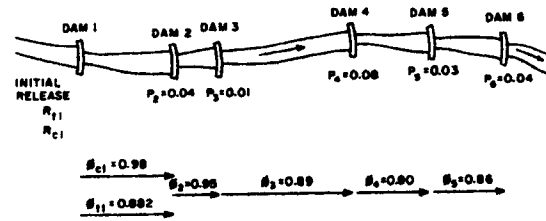

Figure 4. Schematic of the process generating release-recapture data. R fish are released at the most upstream site, and some fraction are detected as they pass dams (in this example). The number that are expected to be detected at dam i is the product of the survival rates from release point to the dam (the ϕ's), the detection probability at the dam (P_i), and the number released. From Burnham et al. (1987).

default analysis in program MARK. In our case, there is a slight added wrinkle caused by alternate pathways (e.g., fish can take a bypass or the mainstem Sacramento), but this does not cause conceptual problems for the analysis: one must add terms for the probability of taking alternate paths.

It is tempting to view our $\approx$ 70 receiver lines as the dams in Figure 2, and try to estimate the 70 or so survival and detection rates from the patterns of detections. With a few hundred fish in a release group and very high survival rates expected for such short distances, we shouldn't expect to be able to learn much about the factors controlling survival at such fine scales (because while noise if low, the signal is even lower). Instead, we will need to define longer reaches such that a significant level of mortality is observed within the reach. Without some preliminary data, we can't know what the scale of these reaches will be. Should survival rates be much lower than expected, a different problem arises: so few fish will be available at downstream sites than the precision of survival rate estimates will be poor. Should this problem become apparent, it could overcome by releasing some groups well down-

3

stream of Battle Creek.

References

Anderson, J. J., E. Gurarie, & R. W. Zabel. 2005. Mean free-path length theory of predator-prey interactions: application to juvenile salmon migration. Ecological Modelling **In press**.

Burnham, K. P., D. R. Anderson, G. C. White, C. Brownie, & K. H. Pollock. 1987. Design and analysis methods for fish survival experiments based on release-recapture. American Fisheries Society Monograph 5, Bethesda, MD.

3.3 Simultaneous analysis of survival and migration

Because migration rate can influence survival by altering the interaction of prey with their predators (Anderson et al., 2005), it would be best to model movement and survival simultaneously. This can be accomplished in a mark-recapture setting using multi-strata models. In these models, the animals move among places (river reaches) and states (live or dead). Given an animal was sighted in a particular place and time in the past, whether it is sighted in another particular place in the future depends on whether it survives the intervening time and moves among the places. We can estimate the transition probabilities (survival and movement rates) and the influences of environmental variables using the same machinery used for the CJS model.

4 Advantages and disadvantages of ultrasonic tagging

The main disadvantages of acoustic tags come from the size of the tag and the cost. The most aggressive researchers are putting V7 tags into smolts as small as 120 mm, but this still limits application. Tags must be implanted surgically, which takes much more time than injecting a full-duplex PIT tag or coded-wire tag. We note that survival experiments using acoustic tags share some difficulties with more traditional approaches including problems of tag shedding and handling effects.

Most of the advantages of ultrasonic tagging come from the ease of "recapturing" tagged individuals. At good sites, it can be easy to achieve 100% detection rates for single fish (if multiple fish are traveling together and moving quickly, it is possible for tags to interfere, allowing some of the group to pass undetected). Furthermore, the hydrophones are relatively inexpensive and can be deployed unattended for months at a time. Finally, each fish is uniquely coded, allowing individual fates to be determined and related to individual traits (including migration history). The net effect is that the movement and survival of individual fish can be followed at a very fine scale, which should make it much easier to detect the effects of environmental manipulations and gain insight into the mechanisms behind the effect.

UNIVERSITY OF CALIFORNIA, DAVIS

BERKELEY · DAVIS · IRVINE · LOS ANGELES · RIVERSIDE · SAN DIEGO · SAN FRANCISCO   SANTA BARBARA · SANTA CRUZ

COLLEGE OF AGRICULTURAL AND
  ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION

DEPARTMENT OF WILDLIFE, FISH, AND CONSERVATION BIOLOGY
ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616-8751
FAX (530) 752-4154

May 27, 2005

Ladd Lougee
Research Coordinator
California Bay-Delta Authority
CALFED Science Program
650 Capital Mall, 5th Floor
Sacramento, CA 95814

Dear Ladd Lougee:

I read the proposal for juvenile salmon tagging by Pete Klimley and NMFS co-PIs Bruce MacFarlane, Steve Lindley and Arnold Ammann with great interest; it would be a natural synergistic companion to our modeling study of Central Valley salmon. I was disappointed to see that CALFED had decided not to include the tag monitoring lines in the ocean, so am writing to provide additional information that the committee may not have considered.

One of our proposed tasks (Task 4) is to investigate the ocean influences on Central Valley salmon. As you may know from our proposal, variability in ocean survival is a dominant uncertainty, it accounts for variability in spawning run abundance of a factor of 10, and most of that variability is determined in the early ocean period. Being able to understand and characterize that variability would reduce the uncertainty in knowing how changes in freshwater management affect salmon. It may also be possible to tailor water management during return years if we can predict ocean the effects of poor ocean conditions on spawning runs.

We will accomplish Task 4 through both a long-term retrospective analysis and shorter-term comparisons with physical and biological information collected recently in the local coastal ocean. That task, especially the latter part, is made difficult by not knowing where the salmon are within the area between the Golden Gate and points north of the Bodega Marine Lab, and how they respond to the weekly scale variability in north/south flows driven by upwelling/relaxation. Obtaining even crude position and timing information from the tag monitors in the ocean at the two lines to the north of the Golden Gate would greatly improve the product of our study. We would at least obtain a time scale for how long they are in the local offshore area, but also would likely obtain information regarding where they are and how they respond to changes in productivity and flows. As noted in our proposal we will be monitoring fluorescence and other biological variables, as well as surface currents as part of the state-funded COCMP project. This could be a great example of several government agencies working together for mutual benefit.

It is clear that acoustic tagging of salmon is an increasing trend, especially with improving technology and smaller tags. In addition to the benefits to our CalFED work, these monitoring stations would allow any researchers (e.g., CDF&G, USF&WS) putting sonic tags in Central Valley salmon to know when salmon were in the area along the coast where conditions related to biological activity are being monitored. They could then have some information on the potential

effects of known ocean conditions. This would increase the power of any future tagging by CalFED or any other agency, to the benefit of CALFED goals. In addition to the Central Valley, having the monitoring stations would augment studies of other systems such as the Russian River.

I hope these comments help in your decision-making.

Sincerely,

Louis W. Botsford
Professor

PORT OF OAKLAND

GERALD M. (Jerry) SERVENTI
Director of Engineering

Tel: (510) 627-1268
Fax: (510) 763-828
E-mail: jservent@portoakland.com

February 3, 2005

Mr. Patrick Wright, Director
California Bay-Delta Authority
650 Capitol Mall, 5th Floor
Sacramento, CA 95814

RE: SUPPORT FOR KLIMLEY AND MACFARLANE PROPOSAL TO INVESTIGATE SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY JUVENILE SALMONIDS

Dear Mr. Wright:

The Port of Oakland facilitates maritime commercial activities in San Francisco Bay that necessitate the construction and maintenance of what are essentially major modifications to near-shore habitats. At the same time, the Port has public trust responsibilities to understand, minimize, and mitigate impacts to the environment. Questions concerning the potential effects of various construction activities on out-migrating salmonid fishes have recently arisen, and our limited ability to address these with existing knowledge has threatened Port development schedules, and indeed, the viability of our seaport. I am writing in support of the above-named research proposal because it represents an opportunity to substantially leverage the research that the Port could fund unilaterally. We have already indicated to NOAA Fisheries our commitment to participate in the Klimley and MacFarlane study, should CALFED fund their proposal.

Klimley and MacFarlane propose to determine the survival and movement patterns of late-fall chinook salmon smolts and steelhead smolts as they migrate from the upper Sacramento River, down the mainstem, through the San Francisco Estuary, and into the ocean. These smolts, from Coleman National Fish Hatchery (CNFH) on Battle Creek, will carry individually coded miniature ultrasonic transmitters placed within their peritoneal cavities. Downstream passage and survival of smolts during outmigration will be recorded by automated, transmitter-detecting monitors placed at sites throughout the watershed and in the coastal ocean to the north and south of the Golden Gate. Some 1,200 fish are proposed be tagged over a three-year period. The only limitation on the knowledge to be gained about migratory patterns will be the number and placement of the monitoring devices. Klimley and MacFarlane and their proposed collaborators will be blanketing the Delta with monitors to provide fine-scale information in that part of the system, but will essentially have only entry and exit points covered for San Francisco Bay proper. The Port of Oakland, along with possibly other groups working in the Bay (e.g., LTMS Science Group, other dredgers and pile driving interests), is eager to participate in the study by purchasing and maintaining a sensor array to provide detailed data on salmon and steelhead movements and habitat use in our vicinity. This information will help build a better picture of how salmonids utilize habitat within the

Letter: Mr. Patrick Wright   February 3, 2005
Re: Support for Klimley and MacFarlane Proposal   Page 2
     to Investigate Survival and Migratory Patterns
     of Central Valley Juvenile Salmonids

Bay. That information can be used to develop management approaches that protect the resources without unduly affecting economic activities such as shipping.

The Port could never, on its own, fund a study of this magnitude. The ability to place monitors into an existing grid, stretching from far upstream of the Bay and into the coastal ocean, will maximize the information return for the Port and Bay Area environmental regulators as well as contribute details to Klimley and MacFarlane's study. We understand that the CALFED Science Program is receiving a large number of solid proposals, but we hope that the quality of this proposal, in addition to the collaborative nature of the work, and the relevance of the information to diverse regulatory contexts, will help your agency decide in favor of the Klimley and MacFarlane proposal.

Sincerely,

Gerald M. Serventi
Director of Engineering

cc: Dr Johnnie Moore, CALFED Lead Scientist
     Mr. David Woodbury, NOAA Fisheries
     Dr Mike Connor, SFEI

February 15, 2005

#313

Mr. Patrick Wright, Director
California Bay-Delta Authority
650 Capitol Mall, 5th Floor
Sacramento, CA 95814

Subject: Letter of Support: Proposal to Investigate Survival and Migratory Patterns of Central
           Valley Juvenile Salmonids (Principal Investigators Klimley and MacFarlane)

Dear Mr Wright:

In 2003, the Long Term Management Strategy for Disposal of Dredged Material in San Francisco
Bay (LTMS), a long-standing collaboration of the San Francisco Bay Regional Water Quality
Control Board, the Bay Conservation and Development Commission, U.S. EPA, and U.S. Army
Corps of Engineers, formed a Science Assessment and Data Gaps Work Group to address the
effects of dredging on sensitive species. I have served as the Group's Chairperson since its
inception.

The Science Group is a consensus-based stakeholder collaboration of representatives from agencies
(BCDC, RWQCB, DFG, USACE, USEPA, NOAA Fisheries, USFWS), dredging proponents
(e.g., Ports of Oakland and San Francisco), dredging community, Bay Planning Coalition,
consulting scientists and others.

The purpose of this letter is to convey to you the support of the Group for the proposed study
referenced above, which we understand has been submitted for funding to the California Bay-Delta
Authority.

The Group has initially focused on fish species and has facilitated development of an assessment
framework which is located at http://www.spn.usace.army.mil/ltms/framework/rpt-USACE-
SciencePlan-Final-Aug04-09170.pdf. This framework document identified as a key study topic,
determination of the distribution of juvenile salmonids (including chinook salmon and steelhead) in
San Francisco Bay. The results of such a study could assist substantially in addressing a variety of
issues associated with dredging activities in the Bay, and was identified as the highest Science
Group priority for funding within the LTMS program.

Drs. Klimley and MacFarlane made a presentation to the Group on their proposed study on
December 7. Following that presentation, there was consensus that it was desirable to collaborate
with this study, if funded. It was the Group's position that collaboration would result in mutually
beneficial leverage of funding and data resources. As a result, the Group in its meeting on January
27 reached consensus that I should write this letter of support. If the Authority decides to fund the
proposed study, the Science Group will recommend allocation of a portion of the available LTMS

budget for this fiscal year to a collaborative study that would augment the proposed study by collecting additional data in the Bay.

Please don't hesitate to contact me via email (phillip.lebednik@lfr.com) or by phone (510-596-9588) if you need additional information concerning this matter.

Sincerely,

Phillip A. Lebednik, Ph.D.
Principal
Ecosystem Services Group

UNIVERSITY OF CALIFORNIA, DAVIS

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

DEPARTMENT OF WILDLIFE, FISH, AND CONSERVATION BIOLOGY   ONE SHIELDS AVENUE
COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES   DAVIS, CALIFORNIA 95616-8751
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION
FAX: (530) 752-4154

15 February 2005

Dr. Johnnie Moore
Lead Scientist
California Bay-Delta Authority
650 Capitol Mall, 5th Floor
Sacramento, CA 95814

Dear Dr. Moore:

The purpose of this letter is to make the California Bay-Delta Authority (CBDA) aware of three additional research projects, which would profit directly from collaboration with the University of California, Davis (UCD) and the National Marine Fisheries Service (NMFS), if the CBDA were to fund the proposed research project, entitled "Survival and Migratory Patterns of Central Valley Juvenile Salmonids." Bruce MacFarlane, Steven Lindley, Arnold Ammann and I were unaware of these projects when we wrote the proposal and thus did not include them under the section for listing opportunities for collaboration.

Firstly, the United States Fish and Wildlife Service is eager to use the proposed array of hydrophones to monitor the downstream migration of steelhead kelts once they have spawned in the tributary adjacent to the Coleman National Fish Hatchery (see attached letter). Mr. Scott Hamelberg, manager of the hatchery, has agreed to provide funds to purchase 30 coded-ultrasonic beacons during Year 1 of our study (and likely more beacons in successive years) to be placed within the peritoneum of adult steelhead once they have spawned in the river. The downstream migration of these tagged steelhead kelts would be detected, given the entire array is established with funding from CBDA, by monitors located at various sites in the watershed, including the (1) junctions between the major tributaries and the mainstem of the Sacramento River, (2) the junction of the river with Grizzly Bay, (3) across the Carquinez Straits, (4) at the mouth of San Francisco Bay, (5) at the entries to all major rivers and sloughs leading into the bay, and (6) by three coastal arrays leading offshore of Monterey Bay, Point Reyes, and Gualala across the continental shelf. The system of hydrophones will enable U.S. Fish and Wildlife scientists to determine the frequency, timing, and spatial accuracy of repeated homing movements made by adult steelhead in the Sacramento River (including straying in other streams).
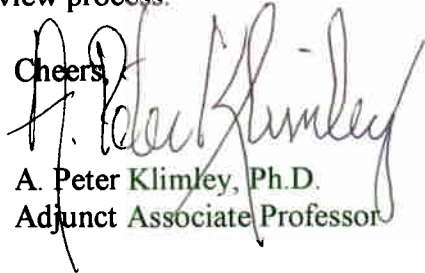
Secondly, Dave Vogel of National Resources Scientists, Inc., informed us during this week that he will be tagging green and white sturgeon with coded ultrasonic tags, detectable by our monitors in a several-mile reach in the middle Sacramento River. The objective of his project is to describe the potential delay and blockage of fishes at a Corps of Engineers hydraulic control compared to nearby natural riffles. In 2003, he placed radio tags on 11 white and 14 green sturgeon for this project. The white sturgeon were captured and in the lower Sacramento River, and unfortunately none migrated upstream far enough to assess the effect of this potential impediment to their upstream migration. Green sturgeon proved to be a better study subject because they migrated further upstream past the study reach. He intends to tag 30

green sturgeon during 2005 and 2006 and record their movements with an array of ten monitors situated along the reach.

Thirdly, the Port of Oakland will be situating ten to 12 tag-detecting monitors at the entry and exit waterways to the port and across the bay bridge in order to assess the effect of shipping and dredging activities on the movements of the Chinook and steelhead smolts that are tagged and released at the Coleman National Fish Hatchery.

Many of us in academia, federal and state agencies, and in private industry are excited about the prospects for collaboration in this ambitious project, provided this array of tag-detecting receivers is in place in the future. Would you please file this letter and the accompanying letter from the U.S. Department of Fish and Wildlife with our proposal, "Survival and Migratory Patterns of Central Valley Juvenile Salmonids," so that they may be considered during the review process.

Cheers,

A. Peter Klimley, Ph.D.
Adjunct Associate Professor

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Red Bluff Fish and Wildlife Office
10950 Tyler Road
Red Bluff, CA 96080
Phone: (530) 527-3043 Fax: (530) 529-0292

TAKE PRIDE
IN AMERICA

FEB 11 2005

Dr. Peter Klimley, Adjunct Associate Professor
Department of Wildlife, Fish, and Conservation Biology
1334 Academic Surge
University of California Davis, California 95616

Dear Dr. Klimley,

The purpose of this letter is to inform you of the U.S. Fish and Wildlife Service's intent to collaborate and benefit from the research project for which you are seeking funding for through the Project Solicitation Package (PSP) of the California Bay Delta Authority (CBDA) Science Program. The proposed project, entitled "Survival and Migratory Patterns of Central Valley Juvenile Salmonids" was submitted jointly by the University of California, Davis and NOAA Fisheries to expand and maintain an array of electronic listening stations (i.e. hydrophones) in the Sacramento River, Bay-Delta, and California coastal waters. We understand that several of these hydrophones are currently being used to monitor movements of adult Chinook salmon and green sturgeon and additional monitoring is planned for white sturgeon, striped bass, splittail minnow and juvenile salmonids. Goals of this proposed project are to describe reach-specific rates of survival and movement of juvenile steelhead and Chinook salmon between the upper Sacramento and into the coastal ocean and to explain variations in these rates in terms of natural and anthropogenic covariates.
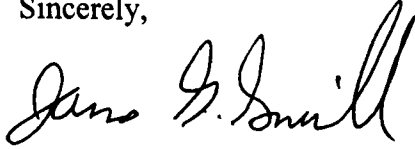
The U.S. Fish and Wildlife Service's Coleman National Fish Hatchery (Coleman NFH) and Hatchery Evaluation Program at the Red Bluff Fish and Wildlife Office (Red Bluff FWO) will participate in this proposed project by providing juvenile steelhead and late-fall Chinook that will be tagged with acoustic transmitters. Our offices agreed to support this research proposal recognizing the potential to gain valuable insights to salmonid migratory patterns. Of particular interest is learning more about salmonid emigration patterns through the lower Sacramento River; an area where a notable dearth of information exists.

More recently, the U.S. Fish and Wildlife Service's Coleman NFH and Hatchery Evaluation Program at the Red Bluff FWO have initiated a complementary study that will utilize the hydrophone array to monitor the migratory patterns of steelhead kelts released from the Coleman NFH. The hydrophones that are currently in place will provide the Service a valuable tool to study migratory patterns of tagged hatchery origin steelhead. Information on movement patterns of adult steelhead in the Sacramento River and estuary is very limited. Additional research projects to evaluate interactions between hatchery and natural salmonids can be envisioned after completion of the expanded array of listening stations. The large-scale acoustic monitoring project proposed by NOAA Fisheries and U.C. Davis will establish a monitoring framework that will provide the U.S. Fish and Wildlife Service and other researchers throughout the Central
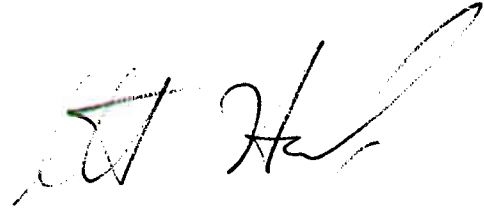
Valley a tool to accomplish fisheries investigations that would otherwise not be feasible by any single management entity.

We appreciate the opportunity to collaborate on this and future research projects using the hydro-acoustic monitoring network established through this project.

Sincerely,

James G. Smith, Project Leader
Red Bluff Fish and Wildlife Office
10950 Tyler Road
Red Bluff, California 96080
Phone: (530) 527-3043 FAX: (530) 529-0292

Scott Hamelberg, Project Leader
Coleman National Fish Hatchery Complex
24411 Coleman Fish Hatchery Road
Anderson, CA 96007
Phone: (530) 365-8622 FAX: (530) 365-0913

Initial Selection Panel Review

Proposal Title

#0313: SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY
JUVENILE SALMONIDS

Funding:

Fund in part
Amount: **$1,300,000**

Initial Selection Panel (Primary) Review

Topic Areas

- Life Cycle Models And Population Biology Of Key Species
- Environmental Influences On Key Species And Ecosystems
- Relative Stresses On Key Fish Species
- Direct And Indirect Effects Of Diversions On At–risk Species
- Implications Of Future Change On Regional Hydrology, Water Operations, And Environmental Processes
- Assessment And Monitoring
- Salmonid–related Projects

Please describe the relevance and strategic importance of this proposal in the context of this PSP. How does the proposal address the topic areas identified above? What are the broader CALFED Goals this proposal may meet that are not accounted for in these specific topic areas?

If implemented as a successful project, this proposal would substantially increase the level of knowledge of juvenile Sacramento salmon and steelhead survival and migratory patterns by applying recently developed ultrasonic biotelemetry techniques. Such information would be valuable for modeling, facilities decisions, planning and many other activities. Therefore this is a highly relevant and strategically important proposal. A better understanding of the residency and survival of juvenile salmonids in various

segments of their migratory path would allow allocation of resources to areas that would most benefit recovery of listed species.

The budgets of proposals submitted in response to this PSP are larger, on average, than those submitted to CALFED in previous years. The Science Program is committed to getting as much science per dollar as is reasonably possible. With this commitment in mind, can the proposed budget be streamlined? If so, please recommend and clearly justify a new budget total in the space provided.

This is an expensive proposed project. The Technical Synthesis Panel concluded that about 40% of the proposal budget ($800,000) has been allocated to deploying ultrasound receiver arrays in coastal waters. If this portion of the budget were deferred, CALFED project costs would be reduced. If the coastal array were not funded by others, survival data for this portion of the migratory pathway would not be available, but the benefits from the upstream data would remain. $2,150,766-800,000=$1,350,766.

Evaluation Summary And Rating.

Provide a brief explanation of your summary rating and any additional comments you feel are pertinent.

CWT (Coded Wire Tag) studies have been the primary approach to tracking smolts in this system for over thirty years. This method, however, has many limitations. The recent innovative radio-telemetry and tracking associated with the Delta Cross Channel studies has demonstrated the value of new methods. The Technical Panel concluded 'that this is one of the strongest salmonid telemetry studies' and that implementation would be very valuable to the CALFED program. Reviewers agreed that this was a very do-able project and that the PI is a recognized leader in his field. This type of telemetry has potential to overcome some key limitations of other methods, particularly CWT. The data on salmon smolt survival and habitat use will be very valuable. However, the application and demonstration of a new, robust smolt tracking methodology to the Central Valley has even greater strategic importance.

Selection Panel (Discussion) Review

fund this amount: $**1,300,000**
note:
fund in part

This proposal would apply a recent attractive ultrasonic tagging technology to elucidate issues of salmon migration. Useful information, including reach-specific data, would come out of this work that is not available through current coded wire tag methodology. The panel suggested that this proposal provides monitoring groundwork with real breakthroughs for understanding of salmon smolt survival in the system. The proposal is not as fine-tuned as others, but this work is important.

This work would supplement an existing data network, using a proven technology the scientists are expert with. In the proposal, the telemetry methodology is superb, but data analysis is not specified clearly enough. Also, the analytical procedures are not supported in the budget, and questions were raised about whether the proposed products would be substantial enough on the analysis front.

DWR and Fish and Game have already invested in these receivers. Use of existing equipment might save money. Several other projects are up and running that utilize this technology for overlapping purposes with other key species.

The panel raised the alternative of not funding this or similar acoustic monitoring proposals, and instead doing a directed action on the topic of biotelemetry, with specific call for proposals in this area in the future.

In the end, the panel preferred to remove the coastal monitoring array component of the proposal (identified as $800,000 by the Technical Synthesis Panel, and fund with this modification.

Panel Ranking: Fund with modification.

Collaboration Panel Review

Proposal Title

#0313: SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY
JUVENILE SALMONIDS

Final Panel Rating
adequate

Collaboration Panel (Primary) Review

Collaboration:

Will the results of the collaborative effort be greater than the sum of its parts? Is it clear why
the subprojects are part of a larger collaborative proposal rather than several independent
smaller ones?

inadequate
The collaborative effort is based primarily two things (1) the
expectation that a few independent studies with similar goals
will be conducted during the same time and (2) the
establishment of a website for uploading shared data.

Interdependence And Integration:

Does the proposal have an example that clearly articulates the conceptual model of each
subproject and how they link together as a whole? Are the boundaries of the study plans
focused and cohesive, yet well delineated? Is there a plan for potential differences in the
stages of subproject completion times? Are there clear plans for analyses and interpretations
which seek to identify and quantify relationships among the data collected in various
subprojects rather than separate analyses for each subproject?

inadequate
No conceptual model of the subprojects are offered in as much
detail as the overall project. The main link is the potential
for sharing data via a website, which will "provide a
coordination interface with other tagging-tracking studies,
through which other researchers can learn of our tag codes and
the locations of our tag-detecting monitors. They will be able

```
to learn whether one of our tagged fish has been detected by
one of their monitors or one of their tagged fish has been
detected by our monitors."
```

Project Management:

Is it clear who will be performing management tasks and administration of the project? Are there resources set aside for project management and time given for investigators to collaborate? Is there a process for making decisions during the course of the project? Are there acknowledgments of potential barriers to collaboration and explanations of how team members will overcome barriers particular to their institutions?

```
inadequate
The principal investigator (A.P. Klimley) is identified as
project manager. His duties as described are "frequent
inspection of the work, coordinate completion of tasks,
supervise graduate students, give scientific presentations,
and prepare jointly authored publications, and assemble the
semiannual reports." No specific time or process is given in
task schedule for meetings.
```

Team Composition:

Does the lead principal investigator have successful management history and experience leading collaborative teams? Is it clear that all key personnel are committed to making significant contributions to the project? Do team members have complementary skills?

```
inadequate
No project management coordination is indicated on his CV. Key
personnel from subprojects are not described as having
complementary skills. From the way the proposal is written, it
does not seem that the lead investigator way sure that the
subprojects would actually be conducted. ("May propose...
"potential for collaboration... "likely to submit a
proposal... etc.") Many personnel have yet to be named.
```

Communication Of Results:

Is there a clear plan for comprehensive and cohesive reporting of project progress to the CALFED community?

adequate
There are plans for a website, symposium and reports.

Additional Comments:

Collaboration Panel (Discussion) Review

Althought the primary reviewer rated most categories as adequate, the secondary reviewer feels the proposal above average. The secondary reviewer noted that the communication of results and establishment of tool for integrated use were good indications of collaboration. For example, the international symposium in particular is an exceptional way to communicate results.

The secondary review also noted that although the study participants do not designate the other people doing similar work as "collaborators" they will be using their site that will encompass the data between all of their teams. In short, they are creating a very simple way to promote collaborating. Definitely, the value will be greater than the sum of it's parts because it would not be too useful by itself.

After both reviewers searched deeper into the proposal for clarity, the overall rating given was Adequate, with the concern that the PI has not demonstrated experience with leading collaborative projects.

Technical Synthesis Panel Review

Proposal Title

#0313: SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY
JUVENILE SALMONIDS

Final Panel Rating
above average

Technical Synthesis Panel (Primary) Review

TSP Primary Reviewer's Evaluation Summary And Rating:

**This is an ambitious biotelemetry survey of Sacramento run
Chinook salmon and steelhead juvenile emigrations and habitat
use patterns across riverine, estuarine, bay, and coastal
habitats. Salmon will be released with miniature acoustic tags
at Coleman National Fish hatchery in the upper Sacramento
River and strategically positioned receivers throughout the
watershed and even in coastal waters will record their
outmigration. Although not specified, map indicates 31
receivers already positioned in Sacramento River with another
21 planned related to this proposal, 8 receivers planned for
the Delta region, 20 planned in San Francisco Bay and another
20 planned in Coastal water arrays (total ~100 receivers).
Migratory paths, rates of migration, residency, and survival
within various segments of the migratory path will be
reconstructed for 200 tagged Chinook and 200 tagged steelhead
juveniles, each of three years. Each ultrasonic tag should
have a life span of >3 months. Tagging effects on survival and
behavior will be evaluated in rearing studies prior to
release. The PI s liken the relocation of each fish by
multiple receivers to a mark-recapture study and suggest that
survival can be similarly estimated following the fate of
individuals destined to emigrate (and ultimate return) from a
given river, Delta, or Bay segment. They then plan to relate**

these migration and survival estimates to a range of watershed and environmental parameters. Evaluation - Superior

Additional Comments:

The PI makes compelling arguments for the appropriateness of the technology to "sample all possible outmigration pathways" and thereby provide critical survival and residency time parameters across numerous segments of the Sacramento River - Delta - San Francisco Bay system. No formal hypotheses or conceptual models related to how migration or habitat use patterns might affect survival and migration rates. Rather the PI argues the need for more exploratory approach to obtain rates and understand from more mechanistic viewpoint likely curtailments on smolt rearing habitats and emigration. The PI is recognized as leader in the field of biotelemetry and reasonable statistical and probability models are erected to evaluate survival associated with patterns of migration. A weaker element is the treatment of habitat variables and lack of a priori survival expectations associated with migration patterns. A lifecycle model is alluded to in the Executive Summary, but never receives explication. This was a very well prepared proposal; plenty of detail on methods and a very nice literature review on the state of knowledge on smolt migration and habitat use patterns in the Sacramento - San Francisco Estuary system. While some literature supports that acoustic tags should be retained in smolts with minimal energetic/behavioral effects, in this new application it would seem prudent to directly test for these effects in rearing experiments. The costs of this proposal is exceptionally high; it was noted in particular that 800 K (40% of the budget) was required for coastal deployment of receiver arrays. This did not seem to jibe with the Delta emphasis of proposal objectives. Coordination and data products are very strong elements of the proposal. Products include. The PI seems well aware of several projects that overlap and could interact (synergistically) with his proposed study. The web-based interface for coordination of projects was a particularly good idea. Reviewers agreed that extremely valuable information on survival and migration rates of juvenile Chinook and steelhead salmon would be generated in this study, that statistical

methods to evaluate "recovery rates" were sound, and that the PI had demonstrated considerable leadership in the field of biotelemetry in coastal systems. Further, although the budget was high and the scale of tagging and receiver locations large, reviewers agreed that the project was very "do-able." Reviewers chief criticisms were the lack of due consideration on assembling relevant habitat attributes associated with the studied reaches and the analysis of that data respective to salmon loss and migration rates. One review criticized the number of smolts as being too few (200 per species per year), but this may need to be balanced due to 1) logistic constraints; and 2) that 200 sample size does not have to match stock abundances, but be sufficiently large to permit internal comparisons. For instance, is 200 fish sufficient to provide comparisons of survival probabilities associated with 6 migration patterns? On the other hand, if survival across many reaches is to be tracked, 200 fish will not get too due to cumulative mortality losses across the system.

This is an ambitious biotelemetry survey of Sacramento run Chinook salmon and steelhead juvenile emigrations and habitat use patterns across riverine, estuarine, bay, and coastal habitats. Salmon will be released with miniature acoustic tags at Coleman National Fish hatchery in the upper Sacramento River and strategically positioned receivers throughout the watershed and even in coastal waters will record their outmigration. Although not specified, map indicates 31 receivers already positioned in Sacramento River with another 21 planned related to this proposal, 8 receivers planned for the Delta region, 20 planned in San Francisco Bay and another 20 planned in Coastal water arrays (total ~100 receivers). Migratory paths, rates of migration, residency, and survival within various segments of the migratory path will be reconstructed for 200 tagged Chinook and 200 tagged steelhead juveniles, each of three years. Each ultrasonic tag should have a life span of >3 months. Tagging effects on survival and behavior will be evaluated in rearing studies prior to release. The PI s liken the relocation of each fish by multiple receivers to a mark-recapture study and suggest that survival can be similarly estimated following the fate of

individuals destined to emigrate (and ultimate return) from a given river, Delta, or Bay segment. They then plan to relate these migration and survival estimates to a range of watershed and environmental parameters. Evaluation - Superior

Technical Synthesis Panel (Discussion) Review

TSP Observations, Findings And Recommendations:

Survival and Migratory Patterns of Central Valley Juvenile Salmonids

Researchers made compelling arguments for their study. Reviewers liked that the researchers plan to follow juvenile salmon though all of their outmigration pathways. The proposal presented no formal conceptual models, but the researchers demonstrated that they know the study system well. The PI is a recognized leader in his field.

A weaker component of the study was the analysis of environmental variables. The researchers did not clearly state which environmental variables they would analyze. The effects of diversions would also be investigated, but the researchers do not provide detail about how this would be done. The number of smolts to be tagged was small due to logistical constraints, but 200 fish per species was considered adequate by one reviewer.

The statistical and mark-recapture approaches were handled well. The researchers have shown that they know how to interact synergistically with other research groups. The data products that would come out of this study would be very useful. This was a well-written proposal, but the life cycle model that was mentioned in the proposal was not presented.

All panel members were not equally impressed with the proposed work. Concerns included the lack of mechanistic hypotheses. The researchers did not develop an expectation for outcomes. The panel liked the emphasis on the Delta, but was not convinced that 40% of the budget ($800,000) allocated to receiver array across the Golden Gate and in the coastal area

was justified in terms of CALFED's priorities.

Some panel members argued that the researcher could have put more effort into understanding the processes that determine where the salmon are going and why. There was a mismatch between the importance of Delta and coastal area arrays to CALFED and the relative budget allocation.

The panel discussed the proposal at length. An advantage of the coastal array is that it could be used to estimate residence time in the estuary. The panel discussed whether the coastal array would be able to detect where most mortality is occurring in the coastal area. Doubts were raised about this.

The panel agreed that this is one of the strongest of the salmonid telemetry studies, and the panel felt that implementation of a high quality telemetry study like this one would be very valuable to the CALFED program

Rating: above average

Technical Review #1

proposal title: SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY JUVENILE SALMONIDS

Review Form

Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea timely and important?

Comments	The objectives are clear, to describe reach specific rates of Chinook and steelhead survival and movement and to explain variations in rates among reaches based on abiotic and biotic features of the reaches. This study proposes to establish a finer level of knowledge about Chinook smolt migration dynamics that has heretofore been unavailable due to the combination of lacking manpower and inadequate technology. As the proposal details, recent technological advances have made it feasible to obtain this finer level of detail without an inordinate amount of manpower. Thus, it is appropriate to use this new technology as soon as possible to better understand Chinook smolt migration.
Rating	very good

Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in the proposal and does it explain the underlying basis for the proposed work? Is the selection of research, pilot or demonstration project, or a full–scale implementation project justified?

Comments	The study is well justified and reviews previous studies in detail. The use of the proposed technology is also well reviewed both with respect to the Delta and Sacramento Valley and with reference to similar

	studies elsewhere. The underlying basis for the proposed work is that previous studies with older technology have provided only limited information about factors that affect Chinook and steelhead smolt migrations and there is virtually no information available at the reach scale. Thus, all descriptive information from this study would be new and could potentially provide more explanatory power than previous work.
Rating	very good

Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

Comments	The approach is well designed and appropriate. A key component will be collaborating with other researchers that have tag monitoring stations to complement the stations deployed for this study. Many surprising results may be found, as is often the case with telemetry studies that have the ability to detect tagged individuals in locations that are not normally included in traditional studies. The approach is feasible and routine in the tradition of telemetry studies. The descriptive information will be new for the Sacramento River and estuaries and will complement ongoing studies in other regions. With respect to the study region, all information will be novel because of the fine scale. Information useful for decision makers could be as simple as determining how many individuals avoid or are entrained by various diversions or as complex as determining that river reaches with certain features are favorable for migration as opposed to others that are not. However, this second objective component is the weakest portion of the proposal. An information

	theoretic approach is proposed to compare environmental attributes of river reaches with smolt migration success. Only a small list of potential 'covariate' (environmental attributes) is provided and no a prior models are presented. This is not a trivial exercise. For this portion of the study to succeed it relies not only on adequate and accurate mark and recapture data but also on appropriate a priori models. It is likely that a wide array of data (e.g., geomorphology, hydrology, predator abundance) are available for the study region and also that knowledge of Chinook and steelhead migration dynamics would support the construction of several models. Environmental attribute data that are not available from literature may be obtainable from maps or aerial photographs or from other researchers. At any rate, a priori models should be based on previous knowledge from peer-reviewed studies and not simply on speculation or convenience. From the proposal it is not clear what information a prior models will be based on. If this study is funded, I recommend a stipulation that a priori models be developed, documented, and approved by peer review prior to initiation of field work.
Rating	fair

Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

Comments	Aside from statistical issues discussed above that relate to the second objective, the approach is well documented and feasible. Both objectives will be limited by the number of Chinook and steelhead smolt 'captures'. This limitation is directly related to the number of released tagged smolts. 200 smolts of each species per year may sound like a large number compared to traditional tagging

studies but it is relatively small (insignificant?) compared to the number of smolts that would have naturally been present prior to large scale human impacts. The tagging approach is conservative by adhering to a low tag weight to body weigth ratio and holding fish for three days post implant prior to release. Thus, it is likely most of the released smolts will survive for a substantial period post release. In addition, the monitoring strategy is impressive in size and will be even moreso if the proposed network with other researchers is successful. Spreading out the releases over three years is also a good idea because it will avoid complete loss if a catastrophy severely impacts the study in a given year. Nevertheless, 600 individuals (per species over the three year study) are still very few and may or may not provide an interpretable record of recaptures. The availability of smolts may be limited but if more are available, I would recommend that an increased number of implanted smolts be considered. It is not clear from the proposal why the number of 200 per species per year was settled on. Why not 400 (20 per day instead of 10 per day)? Why not 600 (30 per day)?

The second objective also relies on development of relevant a priori models for the information theoretic analysis. Thus, the likelihood of success for objective 1 is high but limited by the actions of 200 fish per species per year while the likelihood for success of objective 2 is unclear, being limited by both the actions of the individual fish and the relevance and integrity of a priori models.

Rating	

	`fair`

Monitoring

If applicable, is monitoring appropriately designed (pre–post comparisons; treatment–control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

Comments	`The monitoring is appropriate and will be particularly good if the proposed network between the authors and other researchers in the region is effectively established.`
Rating	`good`

Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the project?

Comments	`Products of value will primarily be the documentation of Chinook and steelhead smolt migration patterns at the reach scale. Insight on the impacts of various reach scale features on Chinook and steelhead migration success is also possible. This information will fit well with efforts to better understand Chinook population dynamics. In addition, the tag monitoring stations will potentially benefit many other telemetry studies ongoing within the region.`
Rating	`good`

Additional Comments

Comments	

Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

Comments	The authors are all successful and accomplished. They are certainly qualified to conduct this research and have already demonstrated access to the infrastructure necessary to accomplish this project. The only question is the qualification and understanding of the information theoretic approach and of environmental factors that potentially affect Chinook and steelhead smolt migration (i.e., covariates that would comprise a priori models).
Rating	very good

Budget

Is the budget reasonable and adequate for the work proposed?

Comments	The budget is large but that is the nature of telemetry studies, which are very labor and equipment intensive. In order to gain new and useful information it is necessary to understand Chinook and steelhead smolt activity at smaller scales and over time (not just at individual points in time) which calls for the sort of study proposed here.
Rating	very good

Overall

Provide a brief explanation of your summary rating.

Comments	I think objective 1 is very important and well documented and likely to be accomplished with my only reservation being the number of smolts to be tagged and released. I would

	prefer to see much stronger justification for this number, preferably an analysis that indicates the number of recaptures will be adequate to form general conclusions, but at least some kind of common sense justification such as 200 per year is the largest number available. Objective 2 is poorly documented although it is highly relevant for restoration efforts. It is subject to limitation by the number of smolts released and also by the lack of explanation and planning regarding the characterization of reaches for comparison and for development of a prior models.
Rating	good

Technical Review #2

proposal title: SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY
JUVENILE SALMONIDS

Review Form

Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea
timely and important?

Comments	The goals (determining migration rate and mortality in specific reaches of the migratory corridor from the hatchery out to sea) are very clearly stated, and they are equally important and timely. This idea is timely in that the technology to accomplish it has only become available in the past few years (miniaturization of transmitters and production of inexpensive, self-contained data-loggers for detecting the transmitters).
Rating	excellent

Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in
the proposal and does it explain the underlying basis for the proposed work? Is the selection
of research, pilot or demonstration project, or a full–scale implementation project justified?

Comments	Information of migration rate and mortality is available for salmonids migrating down the Columbia River system, using the detection of PIT tags at the many dams on the river, and also telemetry in some areas. These data have proven extremely important in assessing the value of water releases for migration speed and survival, survival of different release groupd from hatcheries, modifications of dams and bypass systems, etc. They have really been essential

	`in bringing a scientific perspective to recovery`
	`planning. If one is serious about recovery planning of`
	`salmonids, one simply has to learn about the details`
	`of their migrations and mortality patterns.`

Rating	`excellent`

Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

Comments	`THere are really two aspects to the`
	`approach: fish tracking and analysis of`
	`mortality patterns. The first gets much`
	`more attention than the second, and this is`
	`the only major weakness in the proposal.`
	`Ultrasonic transmitters have gotten smaller`
	`for all the reasons that Klimley indicates,`
	`and they are now getting successfully used`
	`in salmon and steelhead smolts. At the same`
	`time, Vemco developed relatively`
	`inexpensive data-logger/receiver units, and`
	`these work very, very well. My experience`
	`with the VR2 monitoring units has been`
	`entirely favorable. So, the idea of tagging`
	`fish is a very sound approach, as is the`
	`idea of having lots of listening stations.`
	`Effectively, this becomes a mark-recapture`
	`study with multiple, sequential recaptures.`
	`There is a lot of detail on the tagging and`
	`this seems fine. There could have been more`
	`detail about the data analysis, as this can`
	`become quite complicated. The authors might`
	`examine some of the papers by John Skalski`
	`and co-workers on the statistical aspects`
	`of multiple detections of PIT tags on the`
	`Columbia River. If, for example, some fish`
	`are not detected at Site A but are detected`

	farther downriver at Site B, one has to make adjustments in survival estimates for the fish not detected at A or B. Given the large number of reaches, this may not be a trivial matter. In addition, the important aspect of reach-specific attributes related to survival could have gotten more attention. There will be a huge number of variables including but not limited to reach length, width, depth, edge habitat, diversions and inflows, vegetation, salinity, temperature, etc. Making sense of this and determining the factors associated with loss (presumed mortality, though it is always possible that one is tracking the predators rather than the salmon) is not simple. I think determination of travel rates and areas of loss will be pretty simple but the habitat aspects will take some effort, especially considering how many discrete reaches will be involved. My concern is reflected in the fact that the list of tasks is largely confined to tagging fish and maintaining the array of receivers. Those are essential, of course, but to get the real benefit from this project the habitat data need full analysis.
Rating	very good

Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

Comments	It is feasible to tag fish of the sizes that are being proposed, and the receivers to detect such transmitters work fine. The scale of the project is very ambitious, and there will be a

	lot of project management. It will be essential for the main staff not to have many other projects competing for their time.
Rating	very good

Monitoring

If applicable, is monitoring appropriately designed (pre−post comparisons; treatment−control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

Comments	The monitoring will be an integral part of the project, and the nature of the data is such that information will come in smoothly. There is a significant ancillary benefit in the coordination with other tracking projects (e.g., on other fish species).
Rating	excellent

Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the project?

Comments	The main products will initially be reach-specific migration and mortality rate information, and this will be a huge advance in knowledge. Of a much more complex nature will be the explanations for the patterns. The investigators will do some of this work but I suspect that other scientists who are given access to the published data will be able to contribute a lot to their interpretation. I hope that such access to the data, on a collaborative basis, can occur.
Rating	excellent

Additional Comments

Comments	This is a very ambitious but also very do-able project. The weaknesses related to habitat assessment and data analysis can be largely addressed through further collaboration and open access to the data.

Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

Comments	Klimley has long been one of the leaders in telemetry research, and his capabilities are top-notch in this regard. His co-investigators are also very well-qualified. I think they may not have enough help in the statistical end of things, but I have said so already.
Rating	very good

Budget

Is the budget reasonable and adequate for the work proposed?

Comments	The budget is high, but these things do cost money and it is not unreasonable, considering what they propose to do.
Rating	excellent

Overall

Provide a brief explanation of your summary rating.

Comments	This is a really important project that will generate a huge amount of information critical for management decisions. The team can do the work, and I think it should be done. If not, one will be arguing back and

	forth using other forms of data that do not quite meet the needs of decision-makers. It is a bit pricey but worth it.
Rating	excellent

Technical Review #3

proposal title: SURVIVAL AND MIGRATORY PATTERNS OF CENTRAL VALLEY
JUVENILE SALMONIDS

Review Form

Goals

Are the goals, objectives and hypotheses clearly stated and internally consistent? Is the idea
timely and important?

Comments	The goals and objectives are clearly stated. Developing reliable data on the survival and migration rates of juvenile salmon and steelhead in the river, estuary, and nearby ocean are essential to restoring these runs, and will provide extremely valuable information to a number of other studies. The ancillary benefits of the proposed tag detection network to developing information on other species (e.g., sturgeon, striped bass) were described well.
Rating	excellent

Justification

Is the study justified relative to existing knowledge? Is a conceptual model clearly stated in
the proposal and does it explain the underlying basis for the proposed work? Is the selection
of research, pilot or demonstration project, or a full−scale implementation project justified?

Comments	The authors provide an excellent summary of existing knowledge of the status of Chinook salmon and steelhead in the Sacramento River and the value of the improved tagging techniques that are proposed. To some extent, this proposal would augment a valuable tagging and detection system that is being set up elsewhere in the river and estuary.
Rating	excellent

Approach

Is the approach well designed and appropriate for meeting the objectives of the project? Is the approach feasible? Are results likely to add to the base of knowledge? Is the project likely to generate novel information, methodology, or approaches? Will the information ultimately be useful to decision makers?

Comments	The approaches for deploying new tag detectors, integrating with existing detectors, tagging, releasing and monitoring fish, and statistical analysis of the data are all appropriate. The goal of developing better estimates of Chinook salmon and steelhead survival and migration rates is achievable.
Rating	excellent

Feasibility

Is the approach fully documented and technically feasible? What is the likelihood of success? Is the scale of the project consistent with the objectives and within the grasp of authors?

Comments	The approach is well-documented, both in terms of previous uses of these tags and the proposed deployment of new tags/detectors. Based on previous successful use of this technique, the likelihood of developing unique and useful information is good. There is some uncertainty in my mind about the investigators' ability to explain the causes of different reach-specific survival rates. For example, the authors seem to imply that slow movement through a particular reach implies that the reach is a valuable holding/nursery area, whereas it may instead be an area in which smolts are held up too long by inadequate streamflows or confusing current patterns. Such fish may become more susceptible to predators and changes in physiological status (loss of smoltification). That is, slow movement through a reach might imply a situation that needs correction, rather than one to be preserved. How will this be

	`judged?`
Rating	`very good`

Monitoring

If applicable, is monitoring appropriately designed (pre–post comparisons; treatment–control comparisons)? Are there plans to interpret monitoring data or otherwise develop information?

Comments	`General reference is made to the statistical tests`
	`that would be used to analyze the data, although`
	`specific, testable hypotheses were not listed. The`
	`statistical tests seem appropriate. The number of`
	`tagged fish released each year (200 of each species)`
	`is not large, but if the odds of detection in the`
	`multiple arrays are high and the survival is high`
	`throughout the river and estuary, they should be able`
	`to gather useful data. If survival is low in`
	`particular reaches of the river or in the upper`
	`estuary, too few fish will be available to be detected`
	`in the lower estuary and ocean to develop meaningful`
	`survival and migration rates in these areas. It might`
	`be a good idea to release tagged fish at the same time`
	`as other hatchery releases (of untagged fish) in order`
	`to offer some safety in numbers from predators.`

Rating	`excellent`

Products

Are products of value likely from the project? Are contributions to larger data management systems relevant and considered? Are interpretive (or interpretable) outcomes likely from the project?

Comments	`The authors propose a large number of valuable`
	`products, ranging from oral presentations at`
	`conferences to progress reports/open literature`
	`publications/books to a website that shares the data`
	`from the detectors as they are developed. All these`
	`are excellent (and necessary) means of transferring`

	the valuable information gained in the project.
Rating	excellent

Additional Comments

Comments	

Capabilities

What is the track record of authors in terms of past performance? Is the project team qualified to efficiently and effectively implement the proposed project? Do they have available the infrastructure and other aspects of support necessary to accomplish the project?

Comments	The principal investigators have considerable experience with these species and in these aquatic systems. Strong publication record. They appear to be well qualified to carry out the research, analyses, and information transfer tasks.
Rating	excellent

Budget

Is the budget reasonable and adequate for the work proposed?

Comments	Yes
Rating	very good

Overall

Provide a brief explanation of your summary rating.

Comments	The information developed in this proposed research would be of considerable value in understanding the fate of outmigrating juvenile salmonids in the Sacramento River, the estuary and the near-field ocean. The proposal is well-integrated with previous and ongoing work, and additional detectors deployed

	would be useful to other research efforts using other fish species.
Rating	excellent